ELECTRICITY PRICES AS SIGNALS FOR THE EVALUATION OF REFORMS: AN EMPIRICAL ANALYSIS OF FOUR EUROPEAN COUNTRIES

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Electricity prices as signals for the evaluation of reforms: an empirical analysis of four European countries

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Abstract

The paper considers price trends as signals for the evaluation of reforms leading to ownership or market structure changes in public services. In order to do so, we focus on a specific example: electricity prices in four countries, namely UK, France, Germany and Italy.
We consider that these countries offer a natural experiment in different patterns of public/private ownership and liberalisation of electricity industry. We use price changes as a signal and observe that there is no clear dominance of one pattern in terms of welfare change for the representative consumer.
This conclusion tends to reject the widely held idea that one specific "orthodox" pattern should be preferred: privatisation with liberalisation and vertical disintegration. The empirical evidence does not sustain any strong claim of superiority of such a pattern.

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1. Introduction

Processes of privatisation, liberalisation and regulation in the field of public utility services draw increasing attention to the subject of the *performance* of the companies. This term is a generic one and can have different meanings: the profit rate as a *ratio* between gross or net profit and total asset or equity, the *ratio* between profits and revenue, productivity of capital, of labour, or total factor productivity, cost *per* unit produced, *etc.*

The choice of each of these indicators leads to specific conceptual measurement problems, widely discussed in the literature related to regulation systems, in particular with regard to the alternative of a mechanism based on the «RPI-x» criterion or on the rate of return.

However, the economic evaluation of the results of a reform in the field of public utility services should not depend on these corporate indicators. What should be of interest to those who study or plan public policies is the change in the welfare of the various agents that has taken place, or could take place, as a result of the reform.

There are considerably fewer studies on the subject than is actually desirable, presumably because of the greater difficulty in theoretical welfare analysis and in conducting an empirical survey, cf. Megginson, Netter (2001). One of these contributions is Galal et al. (1994), a study carried out on behalf of the World Bank on a limited sample of cases of privatisation; La Porta and Lopez de Silanes (1999) deal with almost all of the companies privatised in Mexico (170 cases, but only a few public utility companies); for the case of electricity in the United Kingdom and, more generally, about public services cf. Newbery (1999), Newbery, Pollitt (1997), Petrazzini, Clark (1996), Boles de Boer, Evans (1996), Domah, Pollitt (2000). Florio (2002) offers a comprehensive review.

The paper considers price trends as signals for the evaluation of reforms leading to changes in public services. In order to do so, we focus on a specific example: electricity prices in four countries, namely UK, France, Germany and Italy.

We consider that these countries offer a natural experiment in different patterns of public/private ownership and liberalisation of electricity industry. We use price changes as a signal and observe that there is no clear dominance of one pattern in terms of welfare change for the representative consumer.

This conclusion tends to reject the widely held idea that one specific "orthodox" pattern should be preferred: namely, privatisation with liberalisation and vertical disintegration. The empirical evidence does not sustain any strong claim of superiority of such a pattern. Further research is needed to understand why European countries offer strikingly different models of industrial organization for the same public service.

The rest of the paper has the following sections: first, we offer a very brief outline of structural differences among electricity industry in selected European countries: France, Germany, Italy, the UK and we mention the Scandinavian countries as well; second, we present an overview of output and consumption electricity trends in the above mentioned four countries; third, we present detailed evidence on price performance and energy inputs costs; fifth, we consider other price explanatory variables; eventually, we conclude with a simple calculation of welfare changes for the four countries and we comment on these findings.

2. Outlines of structural features of electricity industry in selected European countries

The study of the effects of specific public services reforms raises important problems of empirical welfare analysis. The ability to respond to the problems posed is often beyond the possibilities of a single independent scholar, who can only ascertain, with regret, that such an analysis is rarely carried out either by the regulators or by independent researchers, with a few meritorious and important exceptions (cf. *infra*).

For the purpose of illustration, below we shall show how the study of the price trends for a public utility service such as electricity, if carried out using time series and comparisons between countries challenges popular views about the impact of the reforms in Europe.

What follows does not in any way purport to be a comprehensive study of the problem for the sector considered, but merely suggests the need for regulators in different countries, for the European Commission and independent observers to initiate more exhaustive enquiries on welfare changes than are generally available, a subject we shall come back to at the end.

The countries we consider – inevitably very succinctly – are the United Kingdom, France, Germany and Italy, that is the four major member states of the EU. We shall also make some brief reference to the Scandinavian model.

The structural diversity of the electricity industry in these countries is considerable and one issue we are proposing is to verify whether it is possible to capture this diversity through price dynamics, for example confirming the hypothesis that a certain *mix* of privatisation and liberalisation generates sustained reductions in prices.

a) The United Kingdom is obviously the reference case for the restructuring of the sector. The structure of the industry is in continuous evolution and what follows refers to the period covered by the data that we use for the analysis. For an update on the subsequent evolution cf. for example Allen & Overy (2001).

   The United Kingdom is an importer of electricity. In 2000, imports satisfied about 4% of its requirements. The productive mix comprises roughly 76% fossil fuels and the remaining 24% nuclear energy with a negligible percentage of hydroelectric and renewable energy sources.

   The Electricity Act of 31 March 1990 saw the launch of the restructuring of the British electricity sector that had previously operated in a regime of nationalised industry. The reform contemplated the liberalisation and simultaneous privatisation

of the two state companies, National Power and Power Gen, and of the network of RECs (regional electricity companies). The price of the monopoly services (transmission and distribution) was regulated by the *price-cap*, under the control of OFFER, a regulation agency, and later OFGEM, (now GEM, cf. *infra*) managed by a Director General nominated every five years by the minister, who supervises the tariffs, prices and quality of the service offered. In the case of disagreements between the Director General (DGES) and the operators, the antitrust authority, i.e. the Monopolies and Mergers Commission (MCC, now Competition Commission) could interven. An Electricity Exchange (*Pool)* was also set up for the trade of electricity and to determine the prices that the RECs should pay producers[1].

The reform of 1990 (partially modified by the Utility Act of 2000) required that electricity tariffs be divided into the different cost components: production, transmission, distribution, supply and subsidy for nuclear energy. The regulator controls the last four of the five components listed, while the production price is unrestrained. The tariffs are subdivided into tariffs applied to captive users (*franchise market*) and tariffs applied to free users (*non franchise market*). Payment terms are established by each REC and must be approved by the regulating authority.

The tariffs for captive users, in turn, are divided according to the payment terms and the type of tariff. The various types are: *standard* tariff, *day/night* tariff, *day/night controlled circuit* tariff and tariffs with only a variable quota.

The tariffs for free users differ according to whether the annual consumption is higher or lower than 60 MWh. If the consumption is lower than the stated threshold there are four tariffs (*standard*, *day/night*, *evening* and *week-end*). If it is higher then there are *seasonal maximum demand tariffs*.

Recently *flat rate* tariffs have been announced, which are independent of consumption, but based on the number of components of the household and the size

[1] In 2001 the *Pool* was replaced by the New Electricity Trading Arrangements (NETA).

of the home. The new regulation mechanism brought in by the Utility Act of 2000 further modifies the tariff mechanism.

The results of liberalisation were not long in coming: the number of companies producing electricity increased considerably after 1990, from 6 to 47, also thanks to the advent of turbogas technology. Some of the larger ones are National Power, PowerGen, Eastern, British Energy, Magnox Electric and two Scottish firms: Scottish Power and Hydro-Electric. Nevertheless the largest production companies continue to maintain a huge quota of the market and it is believed that in the past they had considerable influence on the formation of prices and on the *Pool*.

Recently there have been phenomena of re-integration and expansion: for example in 1998 Power Gen (a generating company) acquired EME (East Midlands Electricity), the third largest regional electricity company in England and Wales. In March 1999 National Power (a generating company) acquired the British gas distribution company Calortex, etc. As we have already mentioned, the panorama is in continuous evolution and an update on the structural and regulatory scenario can be found on the website of the new sector authority, the Gas and Electricity Markets Authority (GEMA). The new regulation emphasises the role of the authority in protecting the consumers and introduces the Gas and Electricity Consumer Council.

Today, however, the market is totally liberalised. All consumers, domestic and business, can choose their own supplier.

b) France can be considered a symmetrical case to Britain.

France is an exporter of electricity: roughly 16% of the production of EDF, the public monopoly, is sold to Italy, Germany, the UK, Spain and Belgium. The French situation is also remarkable from the point of view of productive mix: in 2000 75% of the electricity produced was generated by nuclear plants, 15% came from hydroelectric and renewable sources and just 10% from fossil fuels. This

situation leads to much lower direct production costs than in the other countries under consideration[2].

On 2 March 2000, France approved a law implementing CE Directive no. 96/92 regarding the liberalisation of the electricity sector, which modified the pre-existing structure created by the law of 8 April 1946. With the reform an authority was set up to regulate the sector and to check that the efficiency objectives agreed in the programme contracts were achieved (direct public control by the Ministries of Industry and of Finance).

The tariffs on the French market are based on three fundamental principles:

- equality of treatment (customers with the same characteristics must pay the same tariffs);
- invoicing at cost-reflective price (a price is applied to each category of consumer that reflects the long term marginal costs of the category itself, including a rate of return on capital);
- the obligation to supply (EDF must at all times satisfy consumers' demands).

Tariffs are divided according to the power supplied:

- blue tariffs (from 3 to 36 kW);
- yellow tariffs (from 36 to 250 kW);
- green tariffs (over 250 kW).

All tariffs also comprise a fixed quota (which depends on the power installed) and a variable amount (consumption and period of use during the day and during the year).

As we said, the reform in France has not yet to a major change in the structure of the sector: around 2000 there there still was a public monopoly or near-monopoly (EDF - Electricité de France) operating at all stages (as a vertically integrated structure), from generation (85% of the market), to transmission (100%), distribution and sales (95%), to single consumers, both domestic and business. As

[2] However there is some public concern about the hidden cost of disposal of nuclear residuals.

regards generation, in addition to EDF there are also other producers including autoproducers (obliged to sell any excess to EDF), distribution cooperatives, state railways and so on. Distribution is managed almost entirely by EDF with 5% managed by distribution cooperatives (usually for private rural supply). An exchange is to be set up in the future to deal in electricity.

c) Germany is only a marginal exporter of electricity. The productive mix includes 63% fossil fuels, 31% nuclear and the remaining 6% hydroelectric and other renewable sources (1999). A gradual move away from nuclear generation is foreseen.

Prior to the reform, the law of 1935 had led to the existence of a *de facto* regime of private regional monopoly with nine vertically integrated supra-regional companies, which, in 2000, still controlled 80% of production, 40% of distribution and all transmission. Below this oligopolistic level that has been static for decades, a regional level operates that is formed of about 80 firms whose principal activity consists of acquiring energy from the large distributors and reselling it at a local level. About 800 entities operate at a local level, most of them publicly owned. 80% of sovra-regional generation is controlled by the first level, and only 20% by regional and local companies.

In 1998 (law of 29 April) the Community directives regarding the liberalisation of the sector were adopted. The reform anticipated total openness: each consumer could choose his own supplier without any limitations or volume threshold. The supplier could also be a producer, a regional distribution company or a municipalized company.

An electricity exchange was also set up, but not an independent sector authority. Control is, in fact, the direct responsibility of the public administration: the Ministry for Economic and Industrial Affairs, regional governments and the antitrust authority (Kartellamt). The first deals with energy policy in the broad sense, while the regional governments authorise the construction of new power

stations, approve tariffs and grant licences for the production, transmission and distribution of power. The antitrust authority verifies the tariffs as well.

For business users the tariffs include a fixed quota according to the maximum quantity of contracted power and a variable amount based on the quantity of energy consumed and the period of use (peak or not). Up until 1996 the tariff also included a compensation tax (which accounted for an average of 8.5% of the final price). This guaranteed the use of German coal in the production of electricity and was collected by the Federal Office for industrial economy. Special tariffs and purchasing obligations are contemplated for the production of energy from renewable sources. About 60% of the electricity sold in Germany today is traded on the basis of two to three year contracts, while small consumers can enjoy standard contracts.

Regarding the results of the reform, it should be said that it is still difficult to evaluate them. On the other hand, liberalisation predominantly affected demand and not supply. However, probably Germany is moving towards a much more accentuated liberalisation of the sector than France.

d) Italy is a net importer of electricity: roughly 15% of demand is satisfied by imports from Switzerland, France, Slovenia and Austria. The current productive mix is the result of a political choice (following a *referendum*) to dismantle nuclear power stations: in 2000 78% of electricity was derived from fossil fuels, and 22% was of hydroelectric origin or from other renewable sources.

With regard to the structure of the sector, after a long period of private oligopoly Italy changed to a vertically integrated public monopoly (1962). Enel, the public sector company, became a Plc in 1992. The adoption of CE Dir. no. 96/92 in March 1999 brought about the liberalisation of the electricity sector in the production, imports, exports, sales and purchasing stages, the deverticalisation of Enel SpA and the constitution of a public company to manage the national transmission system (GRTN SpA). It was also decided to unify distribution in the urban areas, in cases

where the presence of a municipalized company that had survived nationalisation had created dualistic solutions (as in the of AEM in Milan). The reform does not provide for total openness as it does in Germany: since 2000 those with a consumption of over 20 GWh have been able to join the free market, or, within a consortium that consumes at least 20 GWh, those who consume at least 1 GWh. Since 2002 the threshold has been 9 GWh instead of 20 (the limit remains 1 GWh for those belonging to a consortium). If the market were not effectively liberalised it will still be possible to lower the eligibility threshold.

Law 481/95 also provided for the establishment of an Authority for the regulation of electricity and gas. Subjects who possess the eligibility requisites may apply to the said Authority. The new chosen supplier will have to pay a toll (transit) to use the system and related services.

In January 2001 an electricity exchange was set up, a market place in which to make *spot* purchases of energy or stipulate futures contracts (which is not yet operational, but a company has already been set up to manage the market).

A truly open market situation still does not exist in Italy today: the new suppliers can choose the most remunerative customers and thus maintain fairly high price levels. Consequently the service can probably benefit only small business users with high consumption levels who decide to form a *consortium*. By the end of 2003 Enel should be selling off part of its power stations (equivalent of roughly 15,000 MWh of production), by means of competitive procedures.

In addition to Enel, the major suppliers who already, or soon will, operate in Italy include: AEM Milano, AEM Torino, Dalmine Energy, Edison, Enipower, Energy, Merloni Progetto Energy, Sondel, Verbund, ENBW and EDF.

Documents updating the situation in Italy can be found on the Authority's website (www.autorita.energy.it).

e) These four examples are far from being representative of electricity industry across Europe. Particularly, the Scandinavian electricity market has distinctive features.

Sweden is a (marginal) net exporter of electricity. The productive mix is affected by the peculiar geographical position and hydro-geological nature of the country. In 1999 47% of energy was produced using renewable sources, a further 47% was of nuclear origin and just 6% from fossil fuels.

In 1996 there was a radical reform in Sweden, with total liberalisation of production and a regime of authorisation; transmission was still public, in a monopoly regime managed by a non-profit state company, and distribution was delegated to 280 municipalized firms.

In Norway the market has been liberalised since 1991, but state ownership still plays a leading role through local distributors and in some cases also public producers.

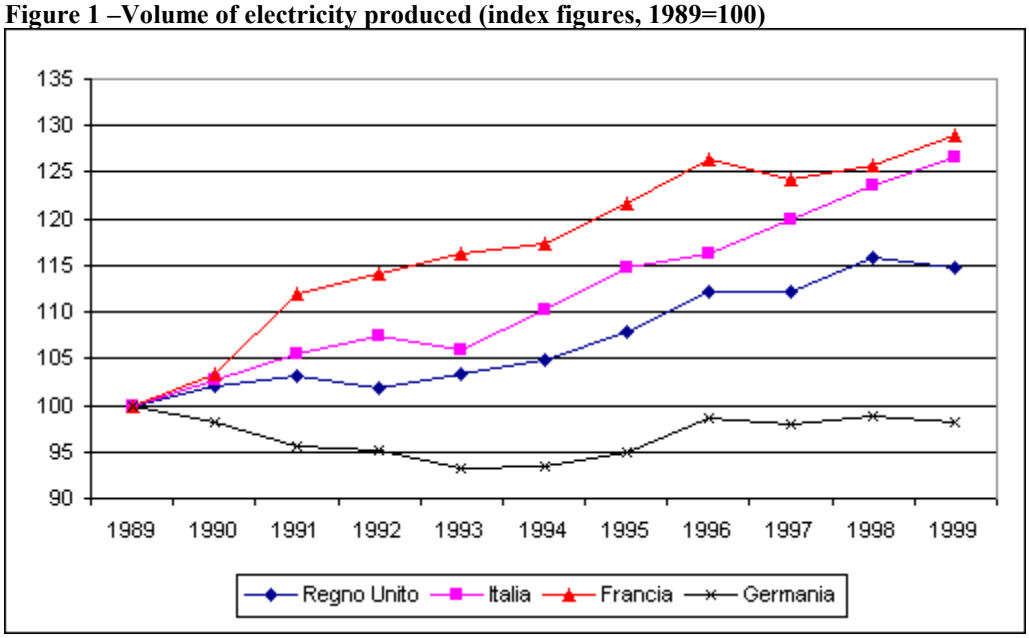
In the Scandinavian electricity area (which will soon also include Finland), liberalisation granted all consumers the freedom to choose their own supplier and in 1996 established the Nord Pool, the electricity exchange in Oslo where all of the Swedish, Norwegian and Finnish firms operate (cf. Amundsen et al., 1998).

As one can see from these very rapid and necessarily incomplete references, in Europe a number of electricity market models coexist that are very different from one another from the point of view of the regime of ownership, degree of openness, productive concentration of the technological *mix* and the degree of vertical integration. We shall now go on to examine output and price trends.

3. *Output and consumption*

We shall begin our discussion by considering production trends.

Figure 1 –Volume of electricity produced (index figures, 1989=100)



Source: our processing of Eurostat data, *Statistiques en bref* 1989-1999

Figure 1 shows the output trend of electricity in Italy, Germany, France and the United Kingdom between 1989 and 1999. For Italy and France the index rose from 100 in 1989 to roughly 130 in 1999, while for the UK growth was only half that amount (about 115). Germany appeared to buck the trend (production was more or less the same).

Over the same period there was a change in the *mix* of sources in the UK: the share of energy from fossil fuels fell from 76.1% to 72.4% (and within this, coal input declined in favour of gas); nuclear increased from 21.7% to 26%; whilst energy produced from renewable sources, which was already marginal, accounted for an even smaller share.

During this time in Italy the quota of conventional fossil fuels remained stable at around 80% and, with the absence of nuclear plants, thus so also did the share of hydroelectric and renewable energy sources (20%). There was a sizeable readjustment in Italy when the nuclear plants were abandoned: between 1986 and 1989, in addition to an increase

of 10% in total production of electricity, there was an increase in the quota of fossil fuels (from 69% to 80%) and a reduction in the hydroelectric (from 25% to 20%).
In Germany the proportions were basically constant for the whole period: roughly two thirds conventional fossil fuels, 30% nuclear and the rest renewable sources.
In France there were no great changes in the productive mix: the nuclear sector claimed the lion's share with 75% (constant over the period), the hydroelectric sector increased slightly (from 12% to 15%) at the expense of fossil fuels (down from 12% to 9%).

Our point here is not to discuss the different trends in production in the countries mentioned, that is something which would require a supply and demand model, considering – amongst other things – that as said above the UK and Italy are net importers, while France and Germany are net exporters. We shall limit ourselves to observing that the differing degrees of liberalisation do not seem to be very important in interpreting the different trends in production. Furthermore, the huge change in the mix of energy sources as a result of the restructuring of the British industry was not accompanied by more sustained production dynamics than in other countries where the source structure remained virtually unchanged. What is striking is the diversity in technological pattern in the countries considered.

Since 1985 the average elasticity of electricity consumption to GDP in the European Union has been around 1 (Annual Energy Review, 1999). However, this mean value conceals great variability among the countries, from the 0.3 of Germany to the 2.9 of Finland. The United Kingdom showed elasticity near to the EU average; while in Italy and France it was almost double (1.9). Per capita consumption was almost 5,000 kWh in Italy (1997), 6,100 kWh in the UK, 6,600 kWh in Germany, 7,400 kWh in France, reaching the continental maximum of 16,540 kWh in Sweden. The table below shows the growth rates of final demand for electricity in the countries considered (Tab. 1).

Table 1 – Average annual growth rates in final demand and in energy consumption *per capita* in some countries (%)

	Final demand		Per capita consumption	
	1985-1990	1990-1997	1985-1990	1990-1997
France	3.6	2.3	2.5	1.8
Germany	1.0	0.5	0.5	0.3
Italy	4.3	2.1	3.8	1.8
Sweden	1.2	0.5	0.8	0.3
UK	2.5	1.7	1.9	1.0
EU	2.7	1.8	2.2	1.2

Source:our calulations on data from Annual Energy Review, EU, 1999

3.1 Prices

With regard to prices in the first analysis we consider the average prices of electricity (including taxes) for business and domestic users. We shall also show the cost trends for some energy inputs.

Figures 2 to 6 show the trends in average electricity tariffs between 1985 and 1997 in the countries studied (data source: Annual Energy Review[3]). These index numbers are based on constant 1990 Euro. Table 1 gives the average rates of growth of prices in the countries studied.

As regards the price to business users in Italy, in a regime of public monopoly and with an unfavourable technological *mix*, between 1985 and 1997 there was a drop of roughly 25%, not that much lower than in France (30%). Despite privatisation, liberalisation and the change in technology, the price reduction in the United Kingdom was not a lot higher at 34%. In Germany price reductions were smaller at the beginning of the period, perhaps also due to the role still played by coal, but in the last two years they fell by 30%, not that far from the 35% recorded in Sweden. The sharp drop in prices in

[3] The data refer to the years 1985, 1988, 1990 and from 1992 to 1997. In order to obtain the missing data we carried out a simple linear interpolation between the observations available immediately before and after.

Germany is linked to the abolition of the compensation tax in 1996 (cf. supra).

In the end, the cumulated changes in price for business users appear to be fairly even for all the countries studied, with a reduction in prices in the region of 30% between 1985 and 1997, albeit with different time profiles.

It is also interesting to compare the costs of the *inputs*, which fell far more than the prices of electricity in all countries.

For example, the price of natural gas fell by about 60% in France, roughly 55% in Germany, 70% in UK and 42% in Italy. The price of diesel oil fell by around 60% in all countries with a peak of 70% in Germany and a minimum of 53% in Italy.

Looking at domestic consumers, the reduction in price in Germany was much lower for them than for business users**,** in the region of 12%. In the United Kingdom domestic users saw their prices fall by 15% (half as much as the reduction for business users). In Italy domestic prices for electricity dropped by 10% compared to 1985, again hardly a generous reduction compared to business users. The French consumers obtained the greatest advantages, with a discount of 25%. Swedish consumers, on the other hand, experienced an increase of 35%.

Thus for all the consumers in the countries considered the reduction in the prices of electricity for domestic use was considerably less generous than that for the business market, except in France (25% vs. 30% respectively).

In the case of domestic users price trends appear to have been quite different in the single countries, evidence perhaps that the markets are less liberalised and competitive than the business supply market.

Fig. 2a - Prices for domestic consumption in Italy (index numbers)

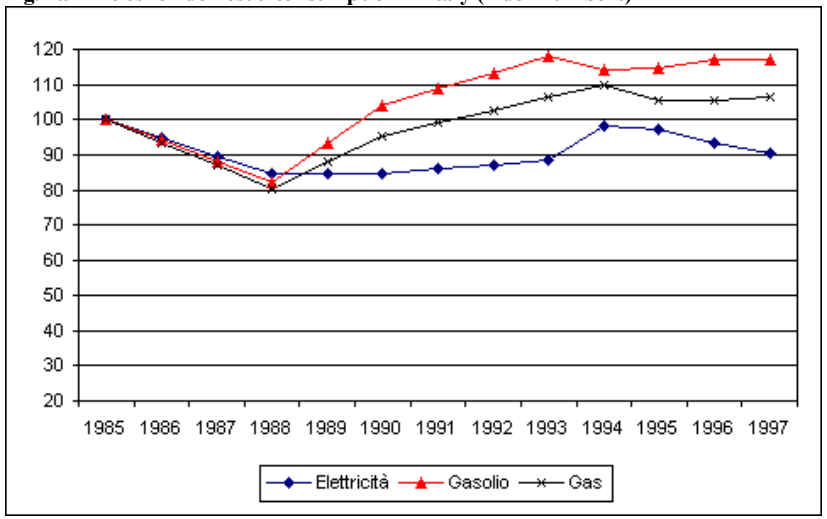


Fig. 2b – Prices for industrial consumption in Italy (index numbers)

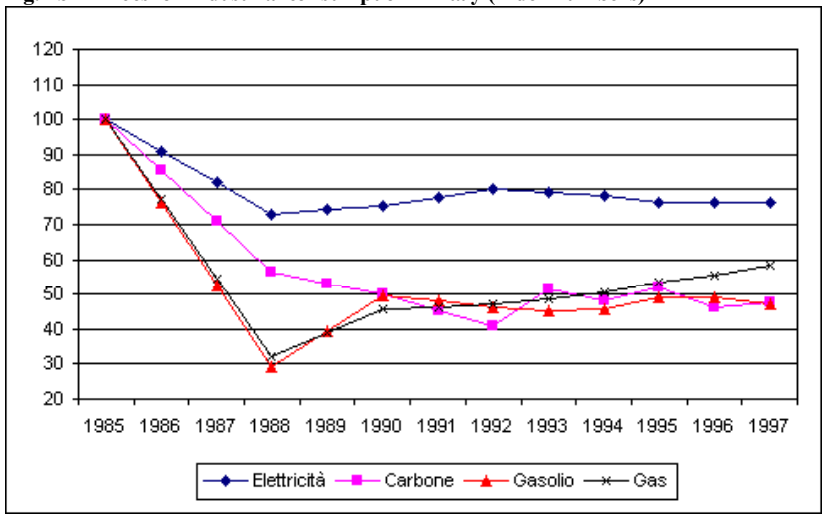


Fig. 3a – Prices for domestic consumtion in the UK (index numbers)

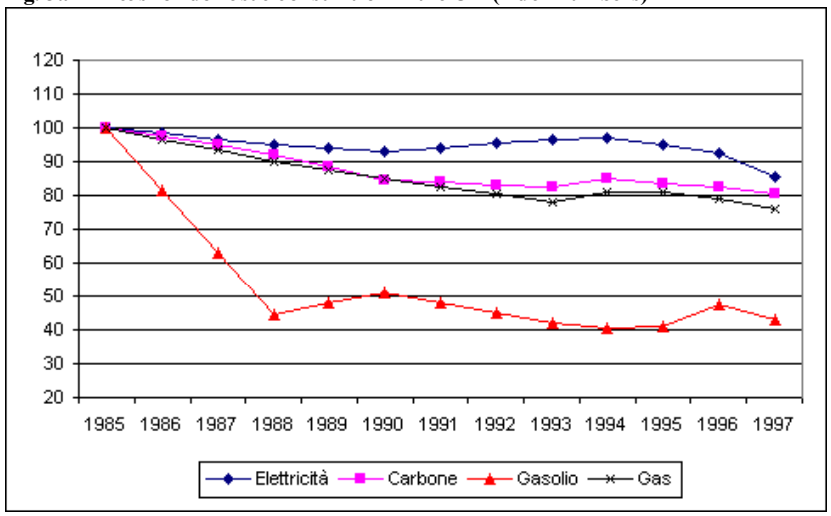


Fig. 3b - Prices for industrial consumption in the UK (index numbers)

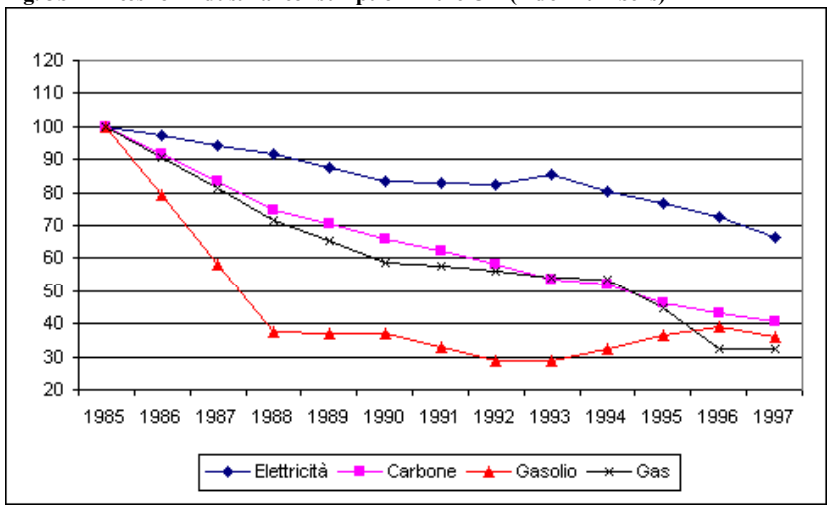


Figura 4a – Prices for domestic consumption in France (index numbers)

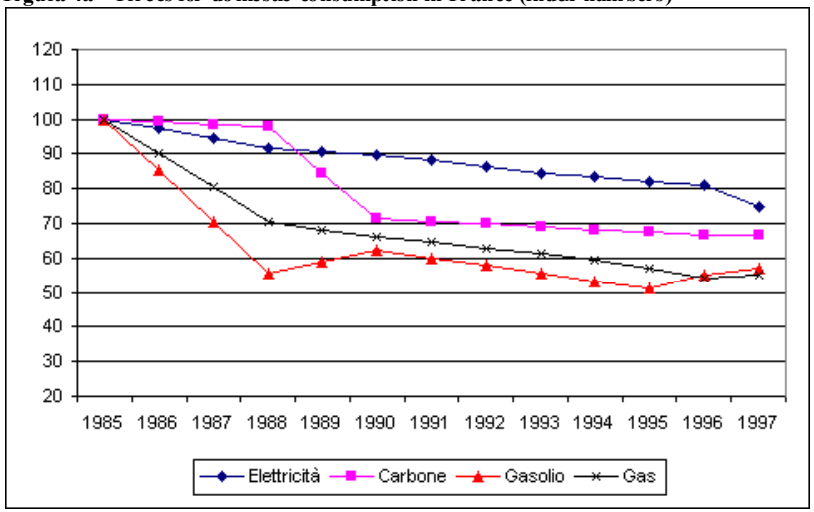
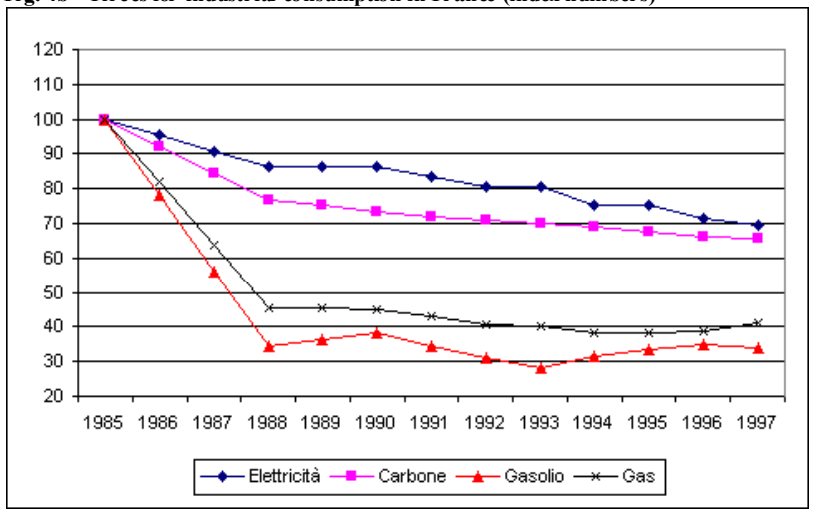


Fig. 4b – Prices for industrial consumption in France (index numbers)



Fig, 5a – Prices for domestic consumption in Germany (index numbers)

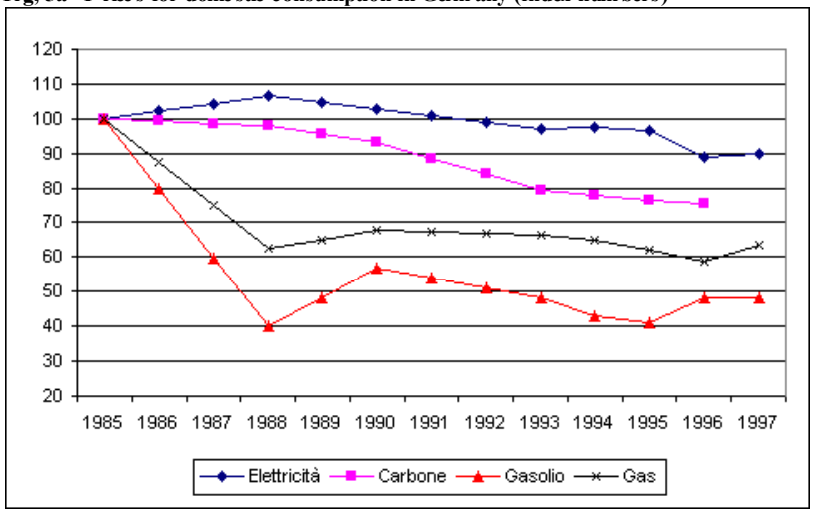


Fig. 5b – Prices for industrial consumption in Germany (index numbers)

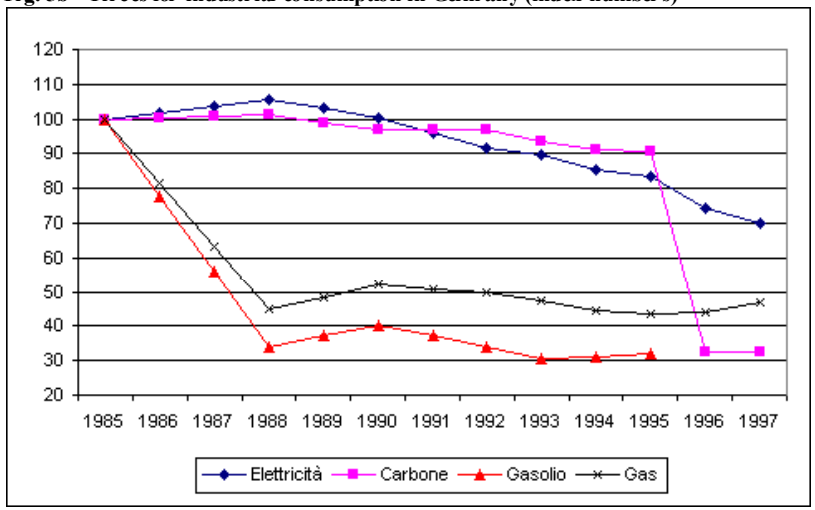


Fig. 6a - Prices for domestic consumption in Sweden (index numbers)

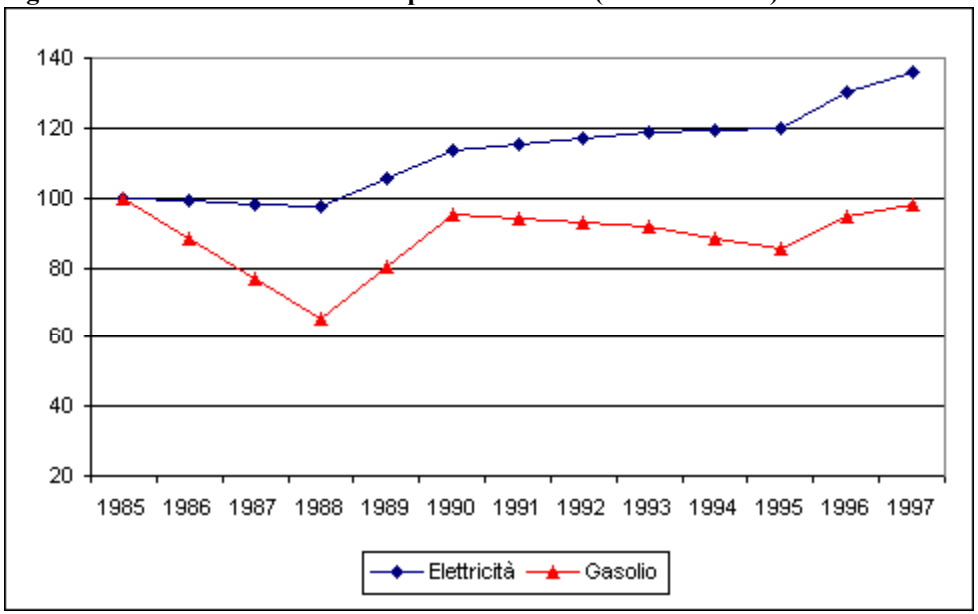
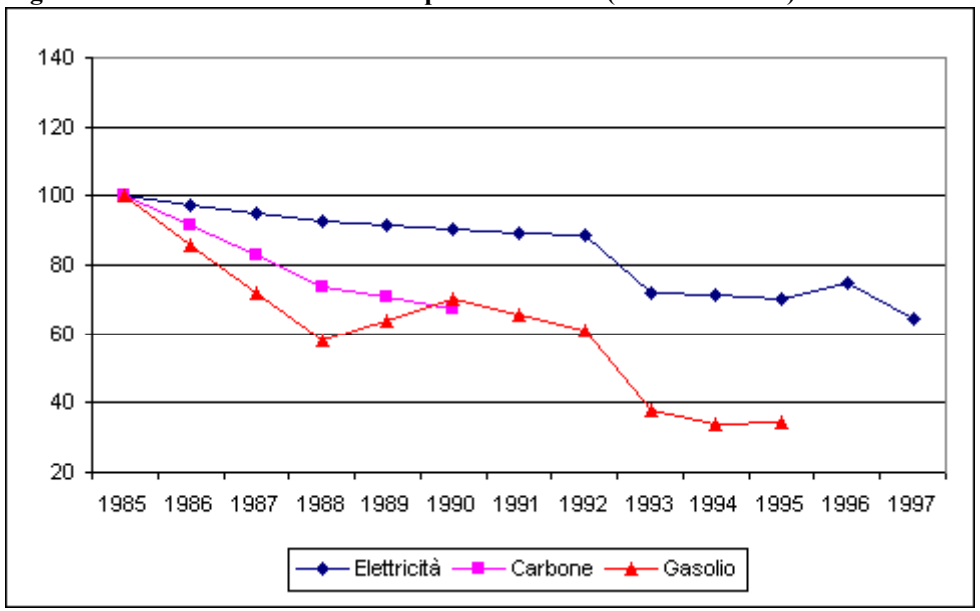


Fig. 6b – Prices for industrial consumption in Sweden (index numbers)



Source: our elaboration of Annual Energy Review data (1997 e 1999)

Table 2 – Average annual percent growth of electricity prices – Business users and domestic users – 1985-1997

	Business users (1)		Domestic users (2)	
	1990-85	1997-90	1990-85	1997-90
France	-2.9	-3.1	-2.1	-2.6
Germany	0.0	-5.0	0.5	-1.9
Italy	-5.4	0.2	-1.4	-1.2
UK	-3.6	-3.2	-1.4	-1.2
EU average	-2.8	-3.2	-1.3	-1.2

(1) Excluding VAT
(2) Including VAT
Source: our calculations on data from 1999 Annual Energy Review, EU, pp.53 and 68

Using the index numbers we have a fairly clear idea of the price trend over the period considered, however, it is less clear in which countries electricity costs more and in which it costs less – see also Tab. 2. Table 3 offers a summary of electricity prices in levels.

Table 3 – Electricity prices for domestic and business users in year 2000, net of taxes, prices in ¤/kWh at current exchange rates

	Residential users (weighted average per class)	Residential users (simple average per class)
France	0,10	0,06
Germany	0,14	0,082
Italy	0,131	0,09
UK	0,129	0,084
Sweden	0,083	0,04
EU average (weighted on consumption)	0,11	0,07

Source: Our calculations on Molinari (2001) and Eurostat data

As can be seen from this table, if we exclude Sweden and France where the prices are clearly lower than the European average, presumably due to the technology used, the prices in Germany, Italy and the UK are not that different from one another, despite the enormous structural differences.

Lastly, we shall now consider the data as a ratio of the real price (net of inflation).

The data for 1990-97 from the International Energy Agency (and published by the OECD), are expressed in terms of real average price and are given in the Table 4 below. We have also listed the Annual Energy Review figures for the same time horizon.

Table 4 – 1997 index of average price in real terms, 1990=100

Country	*Domestic users*		*Business users*	
	IEA	*AER*	*IEA*	*AER*
Italy	106	107	109	101
Germany	83	87	81	70
France	89	83	96	80
UK	91	92	72	79
Average for 20 European countries	105	-	90	-

Source: Paniccia (1999) on IEA data and our processing of Annual Energy Review data (1999)

As we can see in Table 4, the figures from the two sources are far from being identical and show the greatest anomalies for business users.

Eurostat uses an alternative method of sampling and refers to the price per typical consumer.

Table 5 takes the figures published in *Energy Prices* for the period 1985-1998, calculating the appropriate indices for domestic users. We shall consider a typical user with an annual consumption of 3,500 kWh. The figures are gross of indirect taxes and as a control for each country we have taken three series: in local currency, in ECU and in PPP.

For reasons of comparability we shall limit the comparison to the domestic tariffs and to three countries: France, Germany and the UK.

Table 5 - Indices (1985=100) of spending for electricity for a typical domestic user (annual consumption of 3,500 kWh – July 1998)

Country	*ECU*	*Local currency*	*PPP*
UK	119	119	110
Germany	125	111	122
France	110	107	111

Source: Energy Prices, Eurostat

The table shows that for this type of domestic user spending had increased since 1985 in all three countries considered, although there was no obvious pattern.

Paniccia (1999) carried out a comparative analysis for Italy, France, Germany and the United Kingdom for the period 1990-1998 following the "typical consumer" method. The conclusions she reached were the following:

- for smaller domestic users (1,200 kWh) tariffs in Italy fell by 30%, compared to a reduction of 5%-10% in the other three countries;
- for average domestic users (3,500 kWh) tariffs in Italy rose by 30%, (whereas they were stable in the other countries)[4];
- for small business users (160 MWh) and for medium-large users (24 GWh) prices dropped sharply all over (although less sharply in Italy);
- for the largest business users (50 GWh) in Germany prices dropped by 25%, in Italy and France they fell by 5%, and in the UK they rose by 4%.

In Italy the price structure was progressive for domestic users (for a consumer of 600 kWh annually the price is the lowest in Europe), while it is regressive in the other countries. Volume discounts are granted to those who consume more, according to a scheme, which is also used in Italy for business users.

From what we have said one notices how important it is to pay attention to the different methods of sampling and the various sources of statistics.

In this paper, however, we are less interested in carrying out an absolute comparison among the countries, and more interested in trying to understand to what extent the performance of prices and, more generally, the change in the welfare of the consumer, is

[4] This was probably due to special protection offered by law to some "non conventional" independent generators.

linked to privatisation and to the liberalisation of the electricity market. In the following paragraph we take a closer look at this problem using different analysis techniques.

3.2 Empirical analysis

This section is the core of the paper and is divided into three parts:

- firstly we shall attempt to explain the trend in electricity prices on the basis of the trend in the prices of productive inputs;
- then we shall try to verify the existence of a relationship between the trend in prices and other significant variables: consumption, the structure of the sector, the productive mix;
- lastly, we shall try to verify the incidence of sector liberalisation on the welfare of consumers through a simple calculation of the Marshallian surplus.

a) Electricity prices and energy input costs

It is not easy to define an unambiguous acceptable method to determine how much the structure of the sector (more or less marked liberalisation), influences the performance of prices.

A first approach, albeit crude, could be that of studying how much the cost of productive factors influences the price of electricity. If one founds a strong correlation between the above-mentioned variables, one could hypothesise that the mark-up remains constant regardless of the ownership regime and market competition. This type of analysis certainly does not allow one to directly verify the relationship between the degree of liberalisation of the market and prices, but it does constitute a first indirect check. It is worth pointing out that the raw materials taken into consideration (coal, gas and diesel oil) are those most commonly used for the generation of electricity and, consequently, this analysis could bring less satisfactory results for countries with a high percentage of nuclear in the productive mix (France).

Below we shall try to analyse what happens in the single countries and then make a more general comparison. The data used are the same as those presented in Tables 2 to

5 and refer to the period from 1985 to 1997 (remember that we carried out a linear interpolation for the missing figures, cf. note 2). We use the notation "average cost" to indicate a weighted average of the price of productive inputs. The weights used to achieve the average are equal to the percentage claimed by each of the inputs in the production of electricity in each of the countries studied (with 100 being the sum of the three productive factors[5]).

Almost everywhere electricity prices are strongly correlated to those of energy inputs (more so for business users than for domestic ones[6]). The price of coal shows the closest correlation to movements in electricity prices in all countries, for both domestic and business users. For the former the correlation coefficient never falls below 0.65 and is more important than other factors in Germany, whereas in France the coefficient is higher than it is for gas, and in the UK it is the same as gas. For industrial users the coefficient varies from 0.88 (Italy) to 0.96 (Germany) and it is most important for France and Germany, but in the UK it is overtaken by gas and in Italy by diesel oil and gas. In five out of seven cases the average price is between first and second position, but, above all, it never falls below 0.63 for domestic users and below 0.78 for business users. The results obtained thus confirm that there is a strong relationship between the prices of the *inputs* and those of electricity.

The analysis carried out so far can be subjected to two important criticisms. The first refers to the sample, which, from the point of view of a correlation analysis, could be scarcely representative. The second to the possibility that the use of linear interpolation for the unavailable data artificially increases the value of the correlation indices or, in any case, invalidates the results by altering the relative position of the productive inputs in terms of capacity to explain the performance of electricity prices.

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[5] The data referring to the weight of the inputs were taken from the Annual Energy Review (1999). Values are available for the years 1985, 1988, 1990 and from 1995 to 1997. The missing data were obtained by a linear interpolation of the closest available data.

[6] For a detailed country by country analysis and for the correlation tables see section A.1 of the statistical appendix.

As far as the first problem is concerned, since we do not have access to any more complete databases, we can only bear this in mind and use our results with prudence. On the other hand, the literature on the same subject refers – with apparent confidence – to the same sample that we considered (see, amongst others, Steiner, 2000).

With regard to the second question posed above, we shall now repeat the previous tables with the unavailable data calculated as *missing values* (thus eliminating the linear interpolation) and we shall comment on any possible differences compared to previously.

Table 6 – Domestic users – Classification of the inputs according to the correlation with electricity prices

	1	2	3	4
Italy	Gas	Diesel	-	-
UK	Average Price	Coal	Gas	Diesel
France	Gas	Average Price	Coal	Diesel
Germany	Average Price	Coal	Gas	Diesel
Sweden	Diesel	-	-	-

Table 7 – Business users - Classification of the inputs according to the correlation with electricity prices

	1	*2*	*3*	*4*
Italy	Gas	Coal	Average Price	Diesel
UK	Average Price	Gas	Coal	Diesel
France	Coal	Gas	Average Price	Diesel
Germany	Average Price	Coal	Diesel	Gas
Sweden	Diesel	-	-	-

Source: our processing of Annual Energy Review data (1997 and 1999)

If we compare tables 8 and 6 we find that, for domestic users, there was no change in the relative positions of the different productive factors in any country. It should be noted, however, that there was a net relative improvement in both the UK and Germany in the correlation between the weighted average price of input and the price of electricity. In fact, in these countries this value jumps from third and second positions, respectively, to first in the comparison of single productive factors.

If we compare tables 9 and 7 we find that, for business users, the relative positions of the different inputs change only for Italy where the situation passes from the old (1 Diesel, 2 Gas and 3 Coal) to the new order (1 Gas, 2 Coal and 3 Diesel).

Moreover, in all countries there was a change in the relative positions of the average price (from first to third in Italy, from second to first in the UK and Germany, from fourth to third in France).

We may conclude that the interpolation of the missing data did not invalidate the previous conclusions.

Table 8 – Simple correlation (r) between tariffs (residential users) and energy inputs costs.

	Italy	*UK*	*France*	*Germany*	*Sweden*
Coal	-	**0.652**	0.866	**0.827**	-
Diesel	0.290	0.556	0.787	0.140	**0.563**
Gas	**0.534**	0.645	**0.920**	0.253	-
Average cost	-	0.630	0.871	0.767	-

Source: our on calculations on data from Annual Energy Review (1997 e 1999)

Table 9- Simple correlation (r) between tariffs (business users) and energy inputs costs.

	Italy	*UK*	*France*	*Germany*	*Sweden*
Coal	0.885	0.953	**0.937**	**0.960**	-
Diesel	**0.962**	0.695	0.802	0.433	**0.938**
Gas	0.936	**0.975**	0.847	0.403	-
Average cost	0.967	0.953	0.782	0.833	-

Source: our on calculations on data from Annual Energy Review (1997 e 1999)

Table 10 - Simple correlation of electricity prices (residential users) across countries

	Italy	*UK*	*France*	*Germany*	*Sweden*
Italy	1.000	0.399	0.031	-0.394	0.088
UK	0.399	1.000	0.745	0.501	-0.685
France	0.031	0.745	1.000	0.772	-0.935
Germany	-0.394	0.501	0.772	1.000	-0.898
Sweden	0.088	-0.685	-0.935	-0.898	1.000

Source: our on calculations on data from Annual Energy Review (1997 e 1999)

Table 11 - Simple correlation of electricity prices (business users) across countries

	Italy	*UK*	*France*	*Germany*	*Sweden*
Italy	1.000	0.641	0.700	0.269	0.494
UK	0.641	1.000	0.961	0.882	0.859
France	0.700	0.961	1.000	0.863	0.910
Germany	0.269	0.882	0.863	1.000	0.888
Sweden	0.494	0.859	0.910	0.888	1.000

Source: our calculations on Annual Energy Review (1997 e 1999)

b) Electricity prices and other structural variables

This analysis took its cue from an attempt in Paniccia (1999) to verify the relationship between the price of electricity and the following variables:

- the type of equipment used to produce electricity (productive mix);
- total electricity consumption;
- average electricity consumption per inhabitant;
- index of sector concentration.

Paniccia calculates the simple correlation coefficient between average electricity prices (source IEA) and above-mentioned variables for 1996 (the concentration index is the only one that refers to 1997). The study is carried out taking into account the 15 countries of the European Union plus Norway and Switzerland. We repeat this analysis for 1997 taking the prices from two different sources (IEA and the Annual Energy Review).

In table 12 we show the updated data for 1997 for some of the countries and in table 13 a summary of the results achieved when considering all 17 countries.

Table 12 – Production per type of plant and degree of concentration of the market, total consumption and consumption per inhabitant in some EU countries and in Norway (1997)

	Type of generating plant						Degree of concentration of the market	Total consumption		Consumpt. per inhabitant
	Nucl	Fossil	Hydro	Other	Total					
	%	**%**	**%**	**%**	**GWh**	**%**	**%**	**GWh**	**%**	**kWh**
France	78.2	7.9	13.9	0	481,000	100	0.85	380,700	16.7	6,508.6
Germany	31.7	63.4	4.1	0.8	508,300	100	0.17	480,000	21.0	5,852.8
Italy	0	79.2	19.3	1.5	239,900	100	0.63	254,100	11.1	4,422.1
Norway	0	0.6	99.4	0	111,635	100	0.07	113,690	5.0	25,879.8
United Kingdom	26.6	46.0	0.7	26.7	326,066	100	0.22	301,004	13.2	5,110.0
Sweden	46.2	6.6	47.1	0.1	144,931	100	0.32	132,500	5.8	14,981.9
Average EU (15) + Norway and CH	33.7	44.7	17.5	4.1	2,405,079	100	-	2280,964	100	5,921.7

Source: Paniccia (1999) (concentration), Unipede (1998) (type of plants and total consumption), Eurostat (2000) (inhabitants).

Table 13 - Simple correlation coefficients (R) between the level of prices in 17 countries and some explanatory variables (1996-97)

Variable	*Residential users*			*Business users*		
	Paniccia 1999	IEA 1997	AER 1999	*Paniccia 1997*	*IEA 1997*	*AER 1999*
nuclear	0.01	-0.009	-0.01	-0.51	-0.42	-0.47
fossil	0.09	0.35	0.13	0.35	0.07	0.31
hydroelectric	-0.14	-0.38	-0.11	0.21	0.39	0.11
Degree of concentration (*)	-0.10	0.19	-0.13	-0.03	-0.01	-0.14
Total consumption	0.13	0.08	0.10	0.08	-0.09	0.06
Consumption per inhab.	-0.44	-0.66	-0.28	-0.64	-0.55	-0.42

(*) measured with a Hirschman-Herfindahl index

Source: Paniccia (1999) (concentration), Unipede (1998) (type of plants and total consumption), Eurostat (2000) (inhabitants), IEA (2000) and the Annual Energy Review (1999) (prices).

As we can see the correlation between the level of prices and market concentration is very low. In general for business users where the market is probably more competitive, technological variables, which in turn determine costs, are much more important than concentration of supply. The consumption per inhabitant variable, on the other hand, is an indication of the persistence of scale economies and of agglomeration. Besides, a comparison between the price trends for domestic and business users shows that the latter benefit considerably more from the dynamics of falling costs and the increasing doses of liberalisation, even if the lower costs are not always transferred integrally.

At this point we shall again restrict our analysis to Italy, the United Kingdom, France and Germany. The objective is to verify whether the results reached with the method used by Paniccia are also confirmed when following a simple econometric approach.

As usual, the aim is to verify which factors are more important than others in determining price levels in the electricity sector.

The variables considered are: type of generating plants, total consumption, average consumption and a variable of market structure, with the addition, however, of the prices of productive inputs.

As regards the types of generating plants, we use the following definitions:

- *Tot. Q.* The total amount of electricity produced (indices);
- *Q. Hydro.* The amount of electricity produced hydroelectric plants (indices);
- *Q. Nuc.* The amount of electricity produced nuclear plants (indices);
- *Q. Foss.* The amount of electricity produced by fossil fuel plants (indices).

For consumer variables we have used:

- *Tot. Cons.* Total electricity consumption (indices);
- *Av. Cons.* Average electricity consumption per inhabitant (indices).

The variables related to the prices of productive inputs are:

- *Coal P.* The price of coal (indices);
- *Gas P.* The price of gas (indices);
- *Diesel P.* The price of diesel for domestic users (indices).

As regards the magnitude of the structure of the market, in each case the one of the following that gave the most significant results was used[7]:

[7] The data are those from the *OECD International Regulation Database* also used in Steiner (2000) and which can be found on the Internet at http://www.oecd.org/subject/regdatabase. For a more detailed description of them see Steiner (2000) section 3.3.

- Liberalisation;
- Expected time before liberalisation (Time liberal.);
- Privatisation;
- Expected time before privatisation;
- Degree of private ownership;
- Possibility of access to the network by third parties (TPA);
- Degree of vertical integration between generation and transmission;
- Degree of vertical integration between generation and supply;
- Presence of an electricity market;
- Ways of regulating prices.

The method used for this is a regression analysis with "pooled data", a mixture of *cross section* and *time series* techniques. The period considered is from 1989 to 1997.

First and foremost, we note that in one country (Italy) the quantity of electricity produced by nuclear plants over the period studied is zero. This means that when we include the quantity produced by nuclear plants variable in the regression we lose the information pertaining to Italy. It is therefore necessary to divide the study into two parts: with and without Italy, according to whether or not we include the quantity of electricity generated by nuclear plants.

The econometric analysis[8] confirms that the relationship between the prices of electricity and those of productive inputs is stronger for business users than for domestic consumers (for the former two productive inputs enter the regression compared to only one for the latter). This result is in line with those obtained when analysing the correlation.

Tab. 14 – Residential users tariffs. Linear regression

	1 – Without Italy		*2 – Without Italy*		*1 – With Italy*	
	Coeff.	*T-stat*	*Coeff.*	*T-stat*	*Coeff.*	*T-stat*
Constant	51.931	1.490	87.898	2.593	128.633	8.555

Gas Price	0.857	4.156	0.582	3.197	0.229	3.503
Total quantity	0.421	2.992	0.454	2.972	0.273	2.043
Nuclear.	0.106	1.556	0.004	0.075		
Hydro	-0.034	-0.493	-0.132	-2.246	-0.105	-1.316
Average consumption	-0.805	-6.652	-0.742	-5.761	-0.716	-5.417
Liberalization (years expected to)	-0.705	-2.260				
R sq.		0.855		0.818		0.515
R sq.adj.		0.812		0.775		0.452

Source: Our estimation on data from Annual Energy Review (1997 e 1999) prices and input costs), Unipede (1998) (technology and total consumption), Eurostat (2000) (population), OECD(2000) (other structural variables)

Tab. 15 – Business users tariffs. Linear regression

	1 – Without Italy		*2 – Without Italy*		*1 – With Italy*		*2 – With Italy*	
	Coeff	*T-stat*	*Coeff*	*T-stat*	*Coeff*	*T-stat*	*Coeff*	*T-stat*
Constant	86.089	3.963	89.939	3.665	79.288	5.548	74.903	5.258
Coal Price	0.221	4.059	0.262	4.421	0.231	4.258	0.270	5.566
Gas Price	0.550	3.652	0.369	2.446	0.429	3.649	0.348	3.289
Total output	0.024	0.182	0.177	1.312	0.074	0.578	0.046	0.358
Hydro	-0.112	-1.519	-0.181	-2.338	-0.100	-1.444	-0.096	-1.370
Nuclear	0.177	1.910	0.017	0.214				
Thermal					0.023	0.528	0.050	1.250
Average consumption	-0.605	-4.367	-0.451	-3.187	-0.336	-2.607	-0.270	-2.192
Liberalization (expected year to)	-0.823	-2.576			-0.298	-1.464		
R sq		0.899		0.864		0.845		0.833
R sq adj		0.862		0.823		0.807		0.799

Source: Our estimation on data from Annual Energy Review (1997 e 1999) prices and input costs; Unipede (1998) technology and total consumption, Eurostat (2000) population, OECD (2000) other structural variables.

Furthermore, the results obtained are very close to the conclusions reached by Paniccia (1999) regarding the inverse relationship between electricity prices and average consumption per inhabitant.

On the other hand, there are differences in the conclusions regarding the relationship between electricity prices and the variables in the productive mix. In the correlation study strong evidence of an inverse relationship between the quantity of nuclear energy

produced and the price of electricity was found, especially for business users. In the econometric analysis, on the other hand, after having controlled for other variables, it would appear to be the quantity of hydroelectric energy produced that has an inverse relationship with the price of electricity even though the evidence is not very strong.

The most important result of our study, however, is that the two different methods reach the same conclusion regarding the absence (during the period covered by the data considered) of any relationship between industry structure and the price of electricity. In table 16 we summarise the results obtained by each of the methods of analysis (correlation and regression), classifying some factors according to their importance in interpreting the price of electricity (low = 3, medium = 2, high = 1). The factors considered are the price of productive inputs (Input P.), the average consumption per inhabitant (Av. Cons.), total consumption (Tot. Cons.), the quantity of hydroelectric energy produced (Q. Hydro), the quantity of nuclear energy produced (Q. Nuc.) and the structure of the sector (Sect. Struc.).

Table 16 – Importance of some factors in explaining the price of electricity

Variable	*Input P.*	*Average. Consumption.*	*Total. Consumption.*	*Q. Hydro*	*Q. Nuc.*		*Ind. Struc.*
					corr	*reg*	
Domestic	medium	high	low	medium	low	low	low
Business	high	high	low	medium	high	low	low

c) Changes in welfare

Lastly, in this section, we attempt – for purely illustrative purposes - a simple calculation of the *Marshallian surplus* as an average of the Laysperes and Paasche indices (see Hancock, Waddams Price 1997, Florio 2004).

We build on Waddams Price, Hancok (1998) and propose some simple partial equilibrium formulas on consumers' welfare change. For a linear Marshallian demand and its compensated and equivalent counterparts, at privatization, time *1*, we observe quantity x_1 and price p_1. At an arbitrary horizon, time *2*, we observe quantity x_2 and price p_2. These observations lie on the Marshallian demand function. A complication

arises when we have demand shifts, e.g. because of exogenous income change or because changes of consumers' preferences. We ignore this point here.

The compensated demand intersects the Marshallian demand at point x_1,p_1. It takes value x_3 at p_2, where $x_2>x_3>x_1$ because the slope of the compensated demand is greater than the Marshallian demand. We assume that privatized companies produce normal goods. The equivalent demand intersects the Marshallian demand at point p_2,x_2 and takes value x_4 at p_1, and $x_2>x_4>x_3>x_1$.

The Marshallian welfare change caused by price change is

$M = x_1 (p_1-p_2)+ (p_1-p_2) (x_2-x_1)/2$

or

$M = (p_1-p_2)(x_1+x_2)/2$

The Laysperes, Paasche compensated, equivalent variations are respectively:

$L = x_1 (p_1-p_2)$

$P = x_2 (p_1-p_2)$

$CV = (p_1-p_2)(x_1+x_3)/2$

$EV = (p_1-p_2)(x_2+x_4)/2$

Since $x_1<x_3<x_4<x_2$, it follows that $L<CV<M<EV<P$ (see Waddams Price, Hancock, 1998 for a simple graphical presentation).

We define now: $E_1=x_1p_1$. And $E_2=x_2p_2$.

Then

$M = (E_1-E_2+p_1x_2-p_2x_1)/2$

or

$M = \{E_1 (1-p_2/p_1) + E_2 (p_1/p_2 - 1)\}/2.$

Note that

$P = E_2 (p_1/p_2 - 1)$

$L = E_1 (1 - p_2/p_1)$.

Thus we can also simply write that the Marshallian measure is an average of Paasche and Laysperes welfare measures.

$M = (L+P)/2$.

We do not need to know actual prices and quantities, we just need expenditures at privatization and at the final year, and the price index p_2/p_1. Alternatively, if we select an intermediate year when

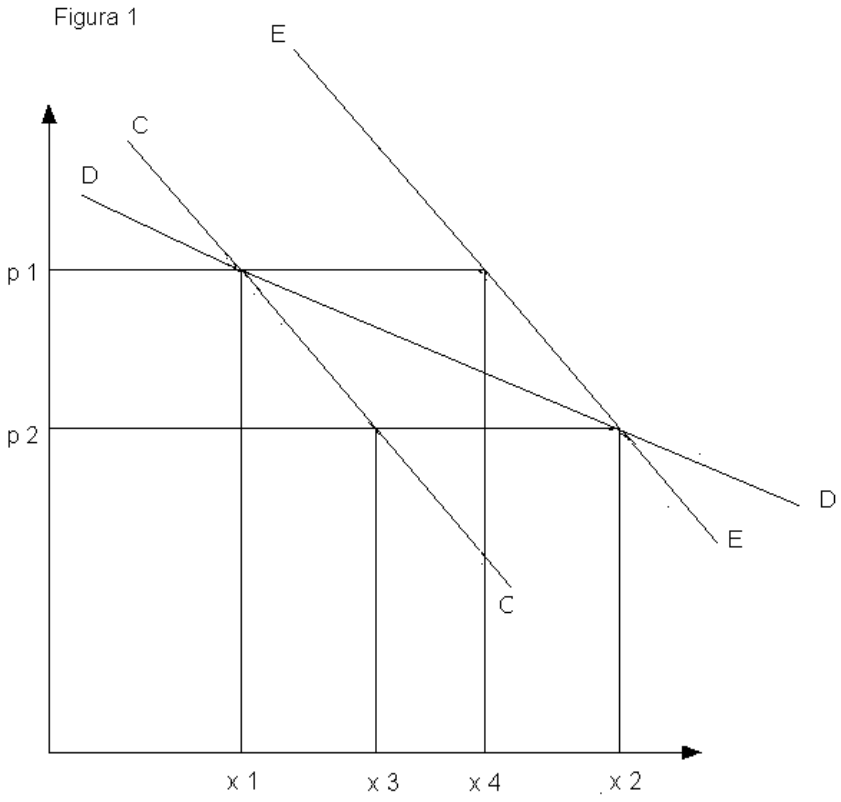
$x^* = (x_1+x_2)/2$ we can directly infer the Marshallian welfare change as

$M = E^* (p_1-p_2)/p^*$.

where we need one midway expenditure data and two price indexes p_1/p^* and p_2/p^*.

We can be confident that this measure is between *EV* and *CV*, when the assumption of linear demand holds and substitution effects are negligible (as they might be for low elasticity of demand). We can then calculate the ratio between *M* and the income of the consumer for different percentiles, and give a welfare weight to each consumer type. Similar reasoning applies to producer surplus, and its changes determined by changes of costs.

We have shown a simplified approach to the empirical estimation of the Marshallian surplus. For a more general approach, with easy to implement measures, see Brau, Florio (2002).



The countries considered are again Italy, the United Kingdom, France and Germany. Data refer to the years 1980 to 1998, the source IEA - Electricity Information (2000), and are unfortunately not comparable with the other sources mentioned. The calculation was made just for the domestic consumers using the figure for total consumption. Prices are expressed in 1990 US dollars to isolate the effects of fluctuations on the currency markets. The values were then converted into their equivalent purchasing power in order to be able to make comparisons.

Tables 17 and 18 give the results obtained at gross prices and net of taxes.

Table 17 - Marshallian surplus (prices gross of taxes) Residential users – 1990 US Dollars* in PPP

	France	*Germany*	*Italy*	*UK*
1980-85	2,881	458	1,031	2,055
1985-90	-4,771	-9,085	-2,223	-3,650
1990-95	-1,702	-4,704	128	234
1995-96	481	2,498	-269	-171
1996-97	2,876	1,963	890	179
1997-98	466	0	126	541

*million

Source: our processing of IEA - Electricity Information data (2000)

Table 18 - Marshallian surplus (prices net of taxes) Residential users – 1990 US Dollars* in PPP

	France	*Germany*	*Italy*	*UK*
1980-85	2,398	452	1,119	2,055
1985-90	-4,012	-7,123	-987	-3,650
1990-95	-968	-3,643	-173	987
1995-96	629	708	-80	-145
1996-97	2,205	1,679	744	75
1997-98	374	211	266	347

*million

Source: our processing of IEA - Electricity Information data (2000)

With this set of data we note that after privatisation (1990) in the United Kingdom the increase in welfare was lower than in France and not very far from that in Italy, despite the fact that the electricity sector had not yet been liberalised in France and Italy.

From what we have said, it is quite clear that it is not possible in this study to infer a precise relationship between the liberalisation of the sector and the change in social welfare, or a clear superiority of one model of industrial organisation over another. Scale economies and input mix dominates on liberalisation as explanatory variables per prices.

4. Conclusion

We feel that the case of electricity is a significant and enlightening one from the point of view of the more general problems mentioned at the beginning of this work.

We have considered output, consumption, prices and consumers' welfare changes over more than a decade in four countries, with very different industry structures.

The available data do not yet allow us to establish which regulatory model and allocation of property rights best protect the consumer from the market power, which in sectors such as electricity, is still a prerogative of the producers and distributors. This is the story told by a study of prices (and quantities). One ingredient of a future critical reading of public policies in this field is a careful monitoring of the trends in prices and

in users' spending, combined with observation over time and an international comparison. This monitoring should not be seen as an end in itself, but as a basis for systematic calculations (*ex-ante* and *ex-post*) of the changes in welfare brought about by the reforms.

In such a perspective it would be desirable - in the absence of a strong European regulator - that an agreement be reached by the national regulators regarding the measurement of prices and consumption in the European Union member states, which would allow calculations of the type suggested here to be made, obviously in a more sophisticated and comprehensive form.

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